

US Patent Application Serial No. 09/921,022
Amendment Dated 11/29/04
Reply to Office Action Dated 9/03/2004

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Amendments to the Claims

The listing of claims will replace all prior versions, and listings, of claims in the application.

Listing of Claims:

1. (Currently Amended) A method for reducing the slew rate of transition edges of a digital signal on an output pad of an integrated circuit, comprising:

connecting a first switchably conductive device characterized by a first threshold voltage of a given polarity between said output pad of said integrated circuit and a voltage source, said first switchably conductive device having a control input connected to a first input signal to allow current conduction from said voltage source to said output pad of said integrated circuit when a voltage level of said first input signal is equal to and greater than said first threshold voltage and to disallow said current conduction when said voltage level of said first input signal is less than said first threshold voltage;

connecting a second switchably conductive device independent from said first switchably conductive device and characterized by a second threshold voltage of said given polarity greater than said first threshold voltage between said output pad of said integrated circuit and said voltage source, said second switchably conductive device having a control input connected to a second input signal to allow current conduction from said voltage source to said output pad of said integrated circuit when a voltage level of said second input signal is equal to and greater than said second threshold voltage and to disallow said current conduction when said voltage level of said second input signal is less than said second threshold voltage;

connecting between said output pad of said integrated circuit and said voltage source one or more additional independent switchably conductive devices each characterized by a respective threshold voltage of said given polarity but different than said first threshold voltage, said second threshold voltage, and each other respective threshold voltage, each said one or more

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additional switchably conductive devices having a respective control input connected to a respective input signal to allow current conduction from said voltage source to said output pad of said integrated circuit when a voltage level of said respective input signal is equal to and greater than said respective threshold voltage and to disallow said current conduction when said voltage level of said respective input signal is less than said respective threshold voltage; and

connecting a driving signal as said first input signal of said first switchably conductive device and as said second input signal of said second switchably conductive device and as said respective input signal of said respective switch of each of said respective one or more additional switchably conductive devices;

wherein said first switchably conductive device, and said second switchably conductive device, and said respective one or more additional independent switchably conductive devices together operate to control the slew rate of said output signal driven onto said output pad of said integrated circuit using a step-controlled edge transition.

2. (Canceled)

3. (Currently Amended) An output driver that drives an output signal onto an output pad of an integrated circuit, comprising:

a first switchably conductive device characterized by a first threshold voltage of a given polarity, said first switchably conductive device coupled between said output pad of said integrated circuit and a voltage source and having a control input connected to a driving signal to allow current conduction from said voltage source to said output pad when a voltage level of said driving signal is equal to and greater than said first threshold voltage and to disallow said current conduction when said voltage level of said driving signal is less than said first threshold voltage; and

a second switchably conductive device independent from said first switchably conductive device characterized by a second threshold voltage of

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said given polarity greater than said first threshold voltage, said second switchably conductive device coupled between said output pad of said integrated circuit and said voltage source and having a control input connected to said driving signal to allow current conduction from said voltage source to said output pad when a voltage level of said driving signal is equal to and greater than said second threshold voltage and to disallow said current conduction when said voltage level of said driving signal is less than said second threshold voltage;

one or more additional independent switchably conductive devices each characterized by a respective threshold voltage of said given polarity but different than said first threshold voltage, said second threshold voltage, and each other respective threshold voltage, each said one or more additional independent switchably conductive devices connected between said output pad and said voltage source and having a respective control input connected to said driving signal to allow current conduction from said voltage source to said output pad when said voltage level of said driving signal is equal to and greater than said respective threshold voltage and to disallow said current conduction when said voltage level of said driving signal is less than said respective threshold voltage;

wherein said first switchably conductive device, and said second switchably conductive device, and said respective one or more additional independent switchably conductive devices together operate to control the slew rate of said output signal driven onto said output pad of said integrated circuit using a step-controlled edge transition.

4. (Previously Presented) An output driver in accordance with claim 3, wherein said first switchably conductive device comprises a single field effect transistor (FET) and single second switchably conductive device comprises a single field effect transistor (FET).

5. (Canceled).

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6. (Currently Amended). An output driver in accordance with claim 5 3, wherein said first switchably conductive device comprises a single field effect transistor (FET) and single second switchably conductive device comprises a single field effect transistor (FET), and said one or more additional switchably independent conductive devices each comprises a single field effect transistor (FET).

7. (Currently Amended) A method for controlling the slew rate of transition edges of a digital signal on an output pad of an integrated circuit, said method comprising the steps of:

driving, with a driving signal, a first switchably conductive device characterized by a first threshold voltage of a given polarity and connected between said output pad of said integrated circuit and a voltage source, said first switchably conductive device having a control input connected to said driving signal to allow current conduction from said voltage source to said output pad of said integrated circuit when a voltage level of said driving signal is equal to and greater than said first threshold voltage and to disallow said current conduction when said driving signal is less than said first threshold voltage;

driving, with said driving signal, a second switchably conductive device independent from said first switchably conductive device characterized by a second threshold voltage of said given polarity greater than said first threshold voltage and connected between said output pad of said integrated circuit and said voltage source, said second switchably conductive device having a control input connected to said driving signal to allow current conduction from said voltage source to said output pad of said integrated circuit when said voltage level of said driving signal is equal to and greater than said second threshold voltage and to disallow said current conduction when said voltage level of said driving signal is less than said second threshold voltage; and

driving, with said driving signal, one or more additional independent switchably conductive devices each characterized by a respective threshold voltage of said given polarity but different than said first threshold voltage,

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said second threshold voltage, and each other respective threshold voltage,
each said one or more additional independent switchably conductive devices
connected between said output pad and said voltage source and having a
respective control input connected to said driving signal to allow current
conduction from said voltage source to said output pad when said voltage
level of said driving signal is equal to and greater than said respective
threshold voltage and to disallow said current conduction when said voltage
level of said driving signal is less than said respective threshold voltage;

wherein said first switchably conductive device, said second switchably
conducting device, and said respective one or more additional independent
switchably conductive devices together operate to control the slew rate of said
output signal driven onto said output pad of said integrated circuit using a
step-controlled edge transition.

8. (Canceled)

9. (Canceled)

10. (Canceled)

11. (Canceled)

12. (Currently Amended) A method for reducing the slew rate of transition edges of a digital signal on an output pad of an integrated circuit, comprising:

connecting a first switchably conductive device characterized by a first threshold voltage of a given polarity between said output pad of said integrated circuit and a voltage source, said first switchably conductive device having a control input connected to a first input signal to allow current conduction from said voltage source to said output pad of said integrated circuit when a voltage level of said first input signal is equal to and less than said first threshold voltage and to disallow said current conduction when said

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voltage level of said first input signal is greater than said first threshold voltage;

connecting a second switchably conductive device independent from said first switchably conductive device characterized by a second threshold voltage of said given polarity less than said first threshold voltage between said output pad of said integrated circuit and said voltage source, said second switchably conductive device having a control input connected to a second input signal to allow current conduction from said voltage source to said output pad of said integrated circuit when a voltage level of said second input signal is equal to and less than said second threshold voltage and to disallow said current conduction when said voltage level of said second input signal is greater than said second threshold voltage;

connecting between said output pad of said integrated circuit and said voltage source one or more additional independent switchably conductive devices each characterized by a respective threshold voltage of said given polarity but different than said first threshold voltage, said second threshold voltage, and each other respective threshold voltage, each said one or more additional switchably conductive devices having a respective control input connected to a respective input signal to allow current conduction from said voltage source to said output pad of said integrated circuit when a voltage level of said respective input signal is equal to and less than said respective threshold voltage and to disallow said current conduction when said voltage level of said respective input signal is greater than said respective threshold voltage; and

connecting a driving signal as said first input signal of said first switchably conductive device and as said second input signal of said second switchably conductive device and as said respective input signal of said respective switch of each of said respective one or more additional switchably conductive devices;

wherein said first switchably conductive device, and said second switchably conductive device, and said respective one or more additional independent switchably conductive devices together operate to control the

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slew rate of said output signal driven onto said output pad of said integrated circuit using a step-controlled edge transition.

13. (Canceled)

14. (Currently Amended) An output driver that drives an output signal onto an output pad of an integrated circuit, comprising:

a first switchably conductive device characterized by a first threshold voltage of a given polarity, said first switchably conductive device connected between said output pad of said integrated circuit and voltage source and having a control input connected to a driving signal to allow current conduction from said voltage source to said output pad of said integrated circuit when a voltage level of said driving signal is equal to and less than said first threshold voltage and to disallow said current conduction when said voltage level of said driving signal is greater than said first threshold voltage; and

a second switchably conductive device independent from said first switchably conductive device characterized by a second threshold voltage of said given polarity less than said first threshold voltage, said second switchably conductive device connected between said output pad of said integrated circuit and said voltage source and having a control input connected to said driving signal to allow current conduction from said voltage source to said output pad of said integrated circuit when a voltage level of said driving signal is equal to and less than said second threshold voltage and to disallow said current conduction when said voltage level of said driving signal is greater than said second threshold voltage;

one or more additional independent switchably conductive devices each characterized by a respective threshold voltage of said given polarity but different than said first threshold voltage, said second threshold voltage, and each other respective threshold voltage, each said one or more additional switchably conductive devices connected between said output pad of said integrated circuit and said voltage source and having a respective control

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input connected to said driving signal to allow current conduction from said voltage source to said output pad of said integrated circuit when said voltage level of said driving signal is equal to and less than said respective threshold voltage and to disallow said current conduction when said voltage level of said driving signal is greater than said respective threshold voltage;

wherein said first switchably conductive device, and said second switchably conductive device, and said respective one or more additional independent switchably conductive devices together operate to control the slew rate of said output signal driven onto said output pad of said integrated circuit using a step-controlled edge transition.

15. (Previously Presented) An output driver in accordance with claim 14, wherein said first switchably conductive device comprises a single field effect transistor (FET) and single second switchably conductive device comprises a single field effect transistor (FET).

16. (Canceled)

17. (Currently Amended). An output driver in accordance with claim 14 16, wherein said first switchably conductive device comprises a single field effect transistor (FET) and single second switchably conductive device comprises a single field effect transistor (FET), and said one or more additional switchably conductive devices each comprises a single field effect transistor (FET).

18. (Currently Amended) A method for controlling the slew rate of transition edges of a digital signal on an output pad of an integrated circuit, said method comprising the steps of:

driving, with a driving signal, a first switchably conductive device characterized by a first threshold voltage of a given polarity and connected between said output pad of said integrated circuit and a voltage source, said first switchably conductive device having a control input connected to said

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driving signal to allow current conduction from said voltage source to said output pad of said integrated circuit when a voltage level of said driving signal is equal to and less than said first threshold voltage and to disallow said current conduction when said driving signal is greater than said first threshold voltage;

driving, with said driving signal, a second switchably conductive device independent from said first switchably conductive device characterized by a second threshold voltage of said given polarity less than said first threshold voltage and connected between said output pad of said integrated circuit and said voltage source, said second switchably conductive device having a control input connected to said driving signal to allow current conduction from said voltage source to said output pad of said integrated circuit when said voltage level of said driving signal is equal to and less than said second threshold voltage and to disallow said current conduction when said voltage level of said driving signal is greater than said second threshold voltage; and

driving, with said driving signal, one or more additional independent switchably conductive devices each characterized by a respective threshold voltage of said given polarity but different than said first threshold voltage, said second threshold voltage, and each other respective threshold voltage, each said one or more additional independent switchably conductive devices connected between said output pad and said voltage source and having a respective control input connected to said driving signal to allow current conduction from said voltage source to said output pad when said voltage level of said driving signal is equal to and less than said respective threshold voltage and to disallow said current conduction when said voltage level of said driving signal is greater than said respective threshold voltage;

wherein said first switchably conductive device, and said second switchably conductive device, and said respective one or more additional independent switchably conductive devices together operate to control the slew rate of said output signal driven onto said output pad of said integrated circuit using a step-controlled edge transition.

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19. (Currently Amended) An output driver that drives an output signal onto an output pad of an integrated circuit, comprising:

a first field effect transistor (FET) device characterized by a first threshold voltage of a given polarity, said first FET device having a source connected to a voltage source, a drain connected to said output pad of said integrated circuit, and a gate coupled to a driving signal; and

a second FET device characterized by a second threshold voltage of said given polarity and different than said first threshold voltage, said second FET device having a source connected to said voltage source, a drain connected to said output pad of said integrated circuit, and a gate coupled to said driving signal;

one or more additional FET devices each characterized by a respective threshold voltage of said given polarity but different than said first threshold voltage, said second threshold voltage, and each other respective threshold voltage, each said one or more additional FET devices having a source connected to said voltage source, a drain connected to said output pad of said integrated circuit, and a gate coupled to said driving signal;

wherein said first FET device, said second FET device, and said respective one or more additional FET devices together operate to control the slew rate of said output signal driven onto said output pad of said integrated circuit using a step-controlled edge transition.

20. (Currently Amended) A method for reducing the slew rate of transition edges of a digital signal on an output pad of an integrated circuit, comprising:

connecting a source of a first field effect transistor (FET) device to a voltage source, a drain of said first FET device to said output pad of said integrated circuit, and a gate of said first FET device to a driving signal, said first FET device characterized by a first threshold voltage of a given polarity; and

connecting a source of a second field effect transistor (FET) device to said voltage source, a drain of said second FET device to said output pad of

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said integrated circuit, and a gate of said second FET device to said driving signal, said first FET device characterized by a second threshold voltage of said given polarity but different than said first threshold voltage; and
connecting respective sources of one or more additional field effect transistor (FET) devices to said voltage source, respective drains of said one or more additional FET devices to said output pad of said integrated circuit, and respective gates of said one or more additional FET devices to said driving signal, said one or more additional FET devices each characterized by a respective threshold voltage of said given polarity but different than said first threshold voltage, said second threshold voltage, and each other respective threshold voltage;

wherein said first FET device, said second FET device, and said one or more additional FET devices ~~first field-effect transistor (FET) and said second field-effect transistor (FET)~~ together operate to control the slew rate of said output signal driven onto said output pad of said integrated circuit using a step-controlled edge transition.

21. (Currently Amended) A method for controlling the slew rate of transition edges of a digital signal on an output pad of an integrated circuit, said method comprising the steps of:

driving a gate of a first field effect transistor (FET) device with a driving signal, said first FET device characterized by a first threshold voltage of a given polarity and having a source connected to voltage source and a drain connected to said output pad of said integrated circuit; and

driving a gate of a second field effect transistor (FET) device with a said driving signal, said second FET device characterized by a second threshold voltage of said given polarity and different than said first threshold voltage and having a source connected to voltage source and a drain connected to said output pad of said integrated circuit;

driving a gate of one or more additional field effect transistor (FET) devices with said driving signal, said one or more additional FET devices characterized by a respective threshold voltage of said given polarity but

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different than said first threshold voltage, said second threshold voltage, and each other respective threshold voltage;

wherein said first FET device, said second FET device, and said one or more additional FET devices ~~first field-effect transistor (FET) and said second field-effect transistor (FET)~~ together operate to control the slew rate of said output signal driven onto said output pad of said integrated circuit using a step-controlled edge transition.